July 2011

SC09A

9-Channel capacitive sensor with auto sensitivity calibration

1. OVERVIEW

1.1 General Description

SC09A is a capacitive sensor with auto sensitivity calibration, and capable of detecting touch on up to 9 electrodes. It allows electrodes to project independent sense fields through any dielectric such as glass or plastic. This capability can lead to entirely new product concepts, adding high value to product designs.

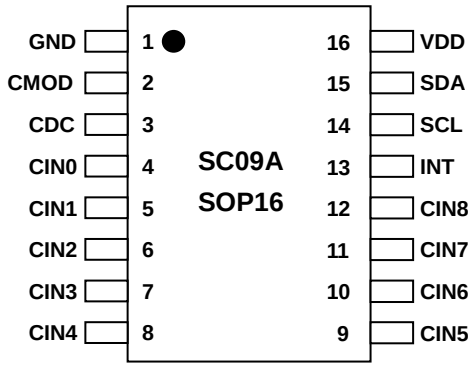
1.2 Features

◇ 9 completely independent touch sensing keys
◇ 100% autocal for life - no adjustments required
◇ Fully debounced results
◇ Multi interface – I^2C serial interface / Parallel outputs
◇ All keys share one sensitivity capacitance
◇ Diffenrent Length of electrodes wires will not lead to different sensitivity
◇ 2.5V ~ 6.0V single supply operation
◇ RoHS compliant SOP16 package

1.3 Application

◇ Mechanical switch replacement
◇ Home appliances (TV, Monitor keypads)
◇ Human interface for Toys & interactive games
◇ Door key-lock matrix application
◇ Switch for light controls
◇ Sealed control panels, keypads

1.4 Package



Package overview

1.5 Pin List

Pin No.	Name	Type	Function	If Unused
1	GND	**Pwr**	Ground	-
2	CMOD	**I/O**	Connected to operation capacitance	-
3	CDC	**I/O**	Connected to sensitivity capacitance	-
4	CIN0	**I/O**	Sence pin 0	floated
5	CIN1	**I/O**	Sence pin 1	floated
6	CIN2	**I/O**	Sence pin 2	floated
7	CIN3	**I/O**	Sence pin 3	floated
8	CIN4	**I/O**	Sence pin 4	floated
9	CIN5	**I/O**	Sence pin 5	floated
10	CIN6	**I/O**	Sence pin 6	floated
11	CIN7	**I/O**	Sence pin 7	floated
12	CIN8	**I/O**	Sence pin 8	floated
13	INT	**OD**	Interrupt indicate	floated
14	SCL	**I**	I^2C clock input	Conneted to Gnd or VDD
15	SDA	**I/O**	I^2C data input/output	Conneted to Gnd or VDD or floated
16	VDD	**Pwr**	Power	-

Pin Type

I	**CMOS input only**
I/O	**CMOS I/O**
OD	**CMOS open drain output**
Pwr	**Power / ground**

1.6 Pin description

VDD, GND

Supply voltage and ground pin

CMOD

Operation capacitance pin should be connected to a fixed capacitance

CDC

Sensitivity set pin the capacitance range is 15pf ~100pf the smaller value the higher sensitivity

CIN0~CIN8

Capacitive sence pins connected to electrodes

INT

After power up, the port will be high impedance. When any key is touched, this port will output a low level.

SCL, SDA

SCL is I^2C clock input pin and SDA is I^2C data input-output pin. SDA ports have a weak internal pull-up resistor.

2. DEVICE OPERATION

2.1 Initial Time

After a power-up reset, the device requires 300ms to initialize, calibrate, and start operating normally. Keys will work properly once all keys have been calibrated after reset.

2.2 Sensitivity

It is decided by the CDC capacitance value. Smaller values of Cdc capacitance make the sensing keys more sensitive.

2.3 Self-recalibration

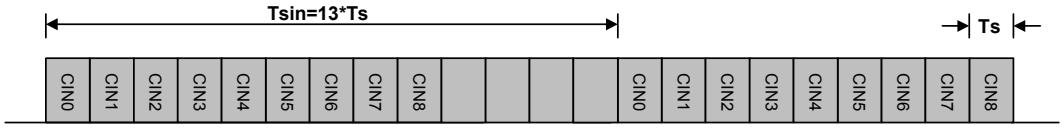
According to the drift of the external environment such as temperature and humidity, the chip will always adjust the reference value of each key except that the chip will stop self-calibrating for about 15s~50s after touching is detected. That is to say continuous touch detection of key will not last over 15s~50s.

2.4 Touching reaction time

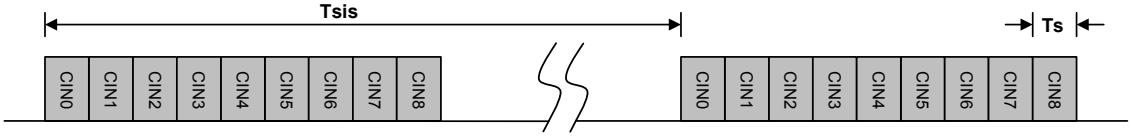
The sample cycle interval in normal mode Tsin is about 12.5ms. After fully debounce, the response time from OFF to ON is about 68ms and the response time from ON to OFF is about 44ms. The max frequence of detecting key is about 9 times / sec.

2.5 Sleep mode

If no key is touched for Tslp and SDA keep high level, the chip will enter sleep mode. In sleep mode the interval of sample becomes larger, and the current consumption Idd becomes small.



sample cycle diagram in normal mode



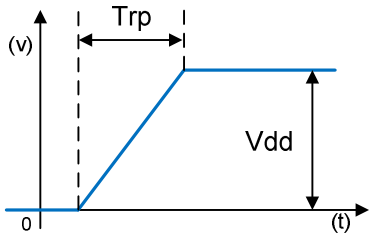
sample cycle diagram in sleep mode

Ts : sample cycle of every key

Tsin : sample cycle interval in normal mode

Tsis : sample cycle interval in sleep mode

Ts and Tsin are fixed in normal mode or sleep mode. Ts is about 950us and Tsin is about 12.5ms. Tsis and Idds(Idd in sleep mode) is dependent with Vdd and Trp (rising time of power on).

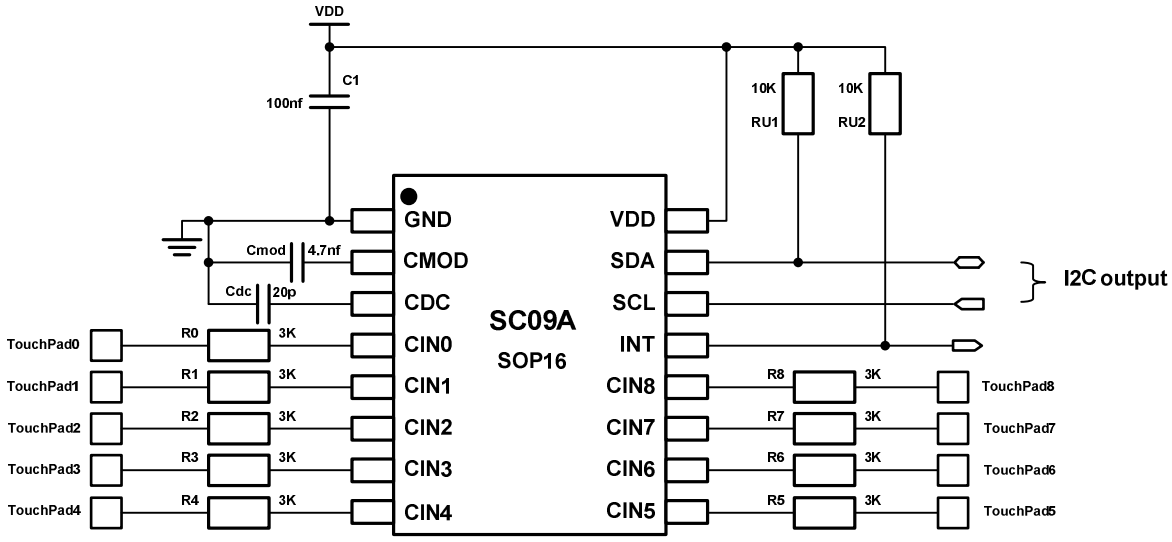


VDD power up curve

Condition / Type value	Vdd=5v					Vdd=3v				
	Trp < 10us	Trp = 100us	Trp = 1ms	Trp = 10ms	Trp > 100ms	Trp < 10us	Trp = 100us	Trp = 1ms	Trp = 10ms	Trp > 100ms
Tsi (ms)	270	252	210	92	67	270	260	245	160	135
Idd (ua)	81	86	104	238	326	39	40	43	65	77
Tslp (s)	86.4	80.6	67.2	29.4	21.4	86.4	83.2	78.4	51.2	43.2

3. Application

3.1 Application circuit

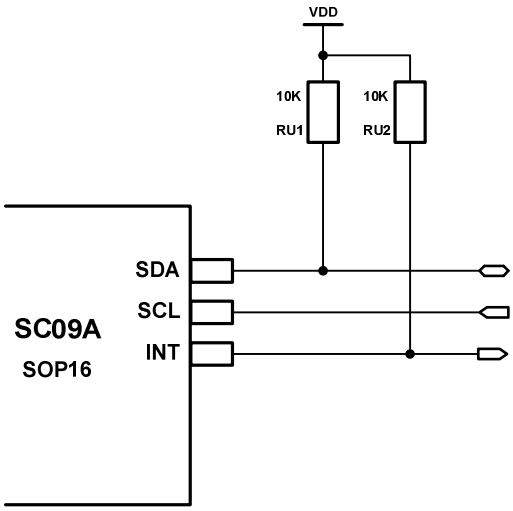


Note:

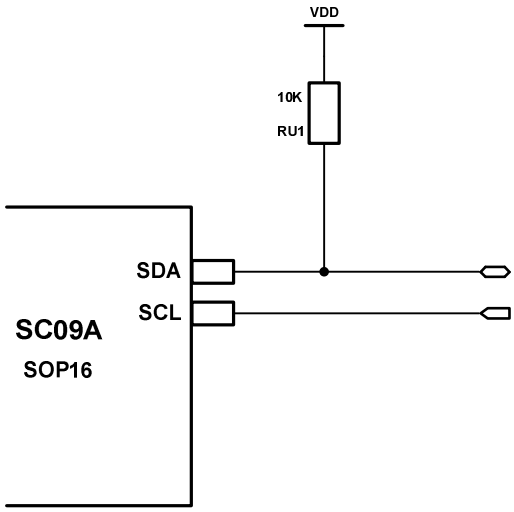
1. Cmod is operation capacitance, the range is 1nf~10nf,4.7nf is suggested.
2. Cdc is sensitivity capacitance, the range is 15pf~100pf. Smaller values of Cdc capacitance make the sensing keys more sensitive.

3.2 Interface with MCU

I²C interface



I²C interrupt Mode



I²C inquiry Mode

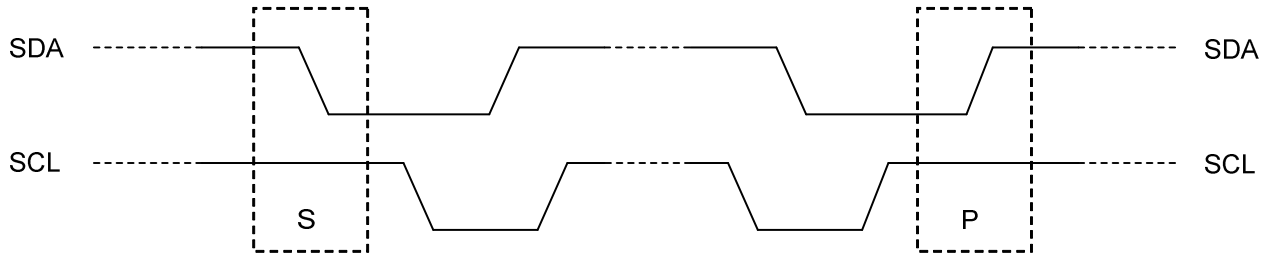
1. Start & Stop condition

Start condition(S)

A HIGH to LOW transition on the SDA line while SCL is HIGH is one such unique case. This situation indicates a START condition.

Stop condition(P)

A LOW to HIGH transition on the SDA line while SCL is HIGH defines a STOP condition.

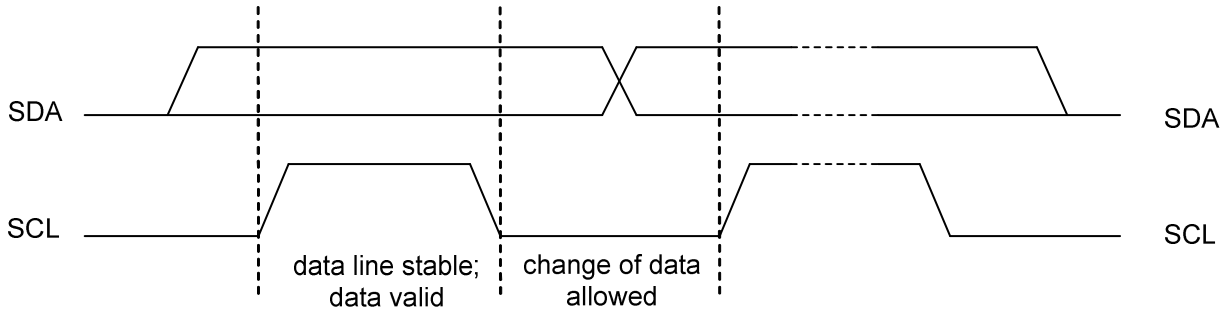


START condition STOP condition

2. Data Validity

The data on the SDA line must be stable during the HIGH period of the SCL line. The HIGH or LOW

state of the SDA line can only change when the clock signal on the SCL line is LOW.



3. Byte format

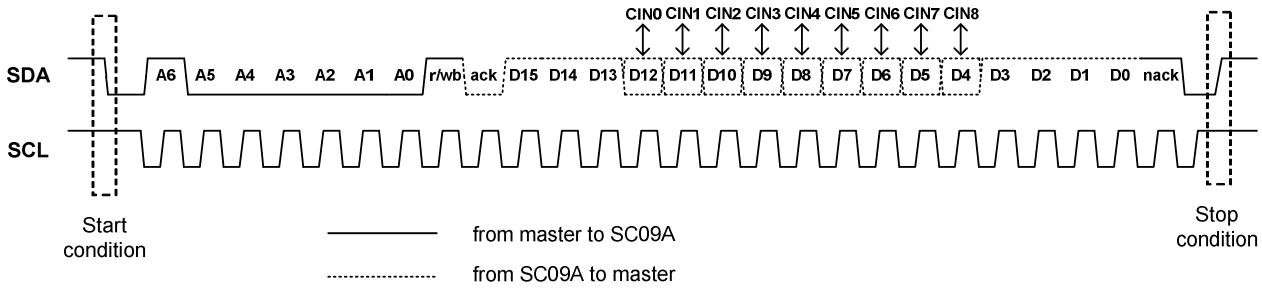
The byte structure is composed with 16 Bit data and an acknowledge signal.

4. The simplified process of communication of SC09A

a) The standard I^2C device has Device Address and Register Address,SC09A only has Device Address.

b) Only read operations is valid to SC09A.

c) Device Address of SC09A is 40H(A[6:0]=1000000B). D15~D13 and D3~D0 are fixed high level, and D12~D4 indicate the corresponding keys CIN0~CIN8 whether is pushed. For example, if the key CIN0 is pushed, D12 will be low level. And if the key CIN0 is not pushed, D12 will be high level.



4. Detailed Parameter

4.1 Absolute Maximum Rating *

Operating temperature	-40 ~ +85ºC
Storage temp	-50 ~ +150ºC
Vdd	-0.3 ~ +6.0V
Max continuous pin current, any control or drive pin	±20mA
Voltage forced onto any pin	-0.3V ~ (Vdd + 0.3) Volts

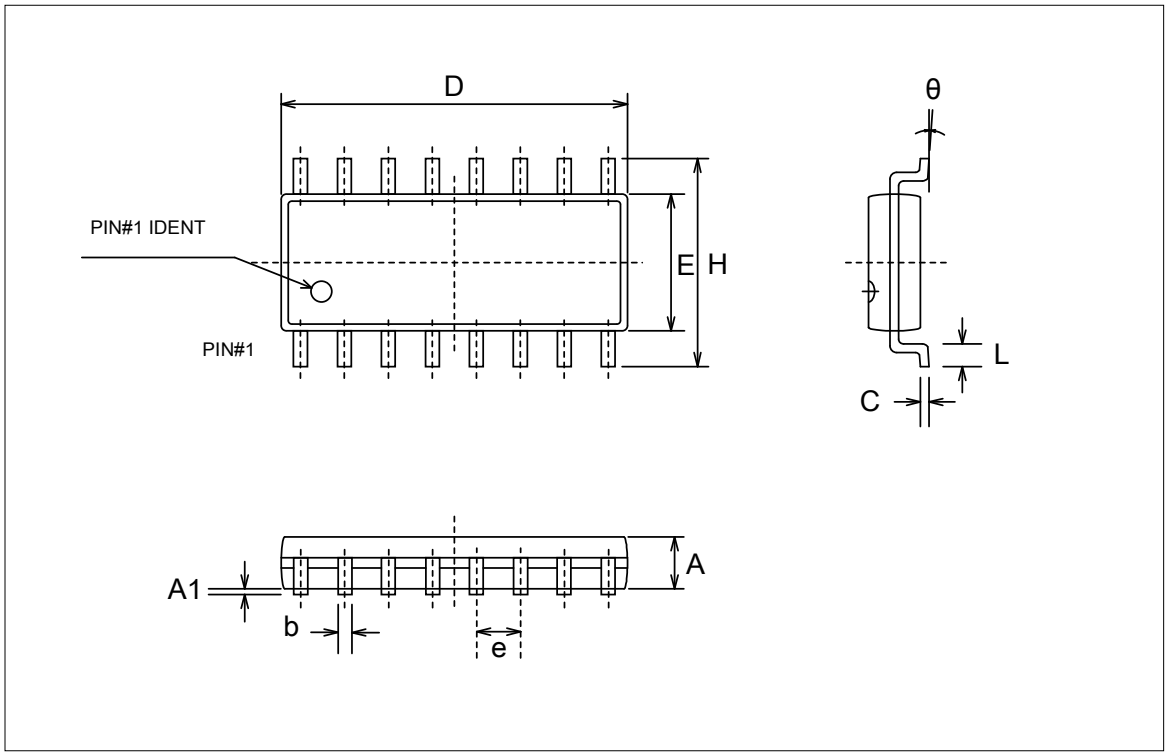
*** NOTICE:** Stresses beyond those listed under “Absolute Maximum Ratings” may cause permanent damage to the device.

4.2 Electrical Characteristics

T_A = 25℃

Characteristics	Symbol	Condition	Min	Typ	Max	Units
Operating Voltage	Vdd		2.5		6.5	V
Current consumption	Idd	VDD=5.0V		1.74		mA
		VDD=3.0V		0.84		mA
Self calibration time after system reset	Tini			300		ms
Sense input capacitance range	Cin				2.5*Cdc[1]	
Output Impedance (open drain)	Zo	delta Cin > 0.2pF delta Cin < 0.2pF		50 100M		Ohm
Output Sink Current	Isk	VDD=5V			10.0	mA
Minimum detective capacitance	delta_Cin	CDC=15pf		0.2		pF
I^2C Max baudrate	F_{br}	PullUp Res = 10K		400K		Bit/S
Interval of sample	Tsi	Normal mode		12.5		ms

4.3 Package Diagram (SOP-16)



Symbol	Dimensions In Millimeters			Dimensions In Inches		
	Min	Nom	Max	Min	Nom	Max
A	1.30	1.50	1.70	0.051	0.059	0.067
A1	0.06	0.16	0.26	0.002	0.006	0.010
b	0.30	0.40	0.55	0.012	0.016	0.022
C	0.15	0.25	0.35	0.006	0.010	0.014
D	9.70	10.00	10.30	0.382	0.394	0.406
E	3.75	3.95	4.15	.0148	0.156	0.163
e	--	1.27	--	--	0.050	--
H	5.70	6.00	6.30	0.224	0.236	0.248
L	0.45	0.65	0.85	0.018	0.026	0.033
θ	0°	--	8°	0°	--	8°

Appendix:

Demo program of C language reading SC09A with I^2C interface

```
// Implemented with MCU AT89S52
#define SDA                 P1_5
#define SCL                 P1_4
#define ERR                 P1_3        // indicate the communication with SC09A is in trouble
#define   CON_ADDR     0x81        // {A[6:0] + RWB} = 81H

unsigned int    ReadKey(void)
{
     unsigned char   bitnum,temp,addr;
     unsigned int     key2byte;
     bit                  bit_temp;
     addr=CON_ADDR;
     key2byte=0xffff;

      EA=0;                                          // disable all interrupt
     SDA=0;                                          // pull down SDA to send START signal
      for(temp=0;temp<4;temp++){}              //delay

                                                     //send 8-bit addr byte (A[6:0]+RWB)
     for(bitnum=0;bitnum<8;bitnum++)
     {
          SCL=0;
          temp=addr&0x80;
          if(temp==0x80)
               SDA=1;
          else
               SDA=0;
          addr=addr<<1;
           for(temp=0;temp<4;temp++){}         //delay
               SCL=1;
             for(temp=0;temp<4;temp++){}     //delay
          }
          SDA=1;                                     //release SDA, SDA is set INPUT port


          SCL=0;
          for(temp=0;temp<4;temp++){}         //delay
          SCL=1;
          for(temp=0;temp<4;temp++){}         //delay
          bit_temp=SDA;
          if(bit_temp)                               //read ack
               ERR=0;                                //ack signal is not found ,error occurs

                                                     //read 16-bit key byte(D[15:0])
          for(bitnum=0;bitnum<16;bitnum++)
          {
               SCL=0;
               for(temp=0;temp<4;temp++){}   //delay
               SCL=1;
               for(temp=0;temp<4;temp++){}  //delay
               bit_temp=SDA;
               if(bit_temp)
               {
                    key2byte=key2byte<<1;
                    key2byte=key2byte|0x01;
               }
               else
               {
```

```
                key2byte=key2byte<<1;
            }
        }
        SCL=0;
        SDA=1;
        for(temp=0;temp<4;temp++){}         //delay
        SCL=1;
        for(temp=0;temp<4;temp++){}         //delay
        SCL=0;
        SDA=0;                              //send NACK
        for(temp=0;temp<4;temp++){}         //delay
        SCL=1;
        for(temp=0;temp<4;temp++){}         //delay
        SDA=1;                              //release SDA, SDA is set INPUT port
        key2byte=key2byte^0xffff;
        EA=1;                               //enable interrupt
        return(key2byte);                   //if the bit is 1 means the key is pushed. for example, the return
                                            value //is 0x0500 means that the key CIN2 and CIN4 are pushed.
}
```